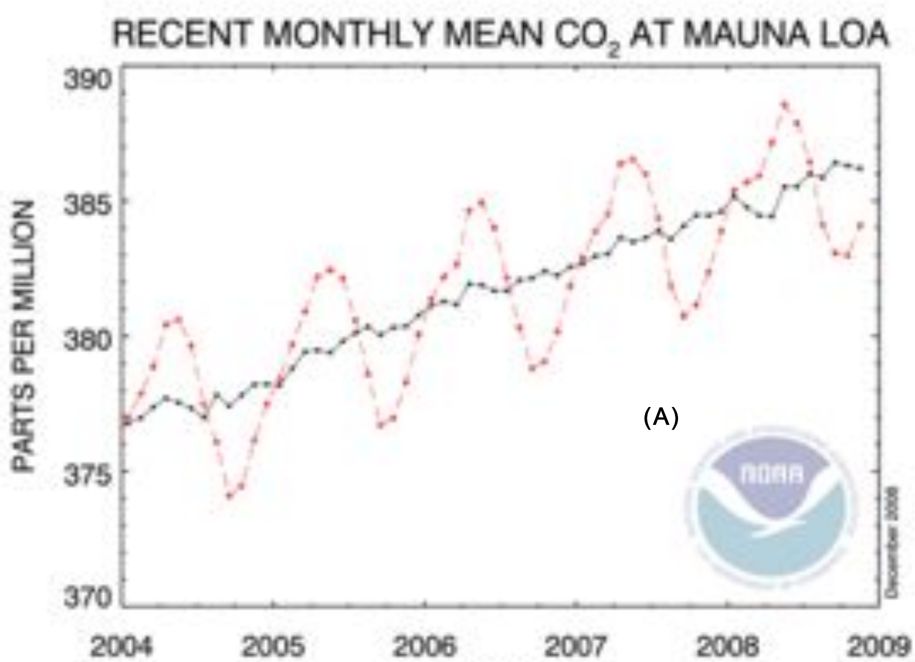
Trees, Carbon and Climate Change

Current policy discussions about climate change suggest that forestry is an inexpensive way to capture atmospheric carbon dioxide and potentially reduce forecasted climate change. This fact sheet discusses which forestry practices are being considered to capture carbon dioxide and how landowners might engage in trading as carbon markets develop.

Background

In late 2008 the US National Oceanic and Atmospheric Administration (NOAA) atmospheric observatory in Hawaii documented atmospheric carbon dioxide (CO_2) concentration of 386 parts per million by volume (ppmv). This is the highest atmospheric concentration of carbon dioxide ever recorded since monitoring has begun. Even accounting for seasonal variations (Figure 1), recorded evidence indicates a steady increase in atmospheric CO_2 levels. Although the full extent and future impacts of CO_2 increases are uncertain, current models predict a rise in temperature, climate shifts and sea level rise.

Figure 1. Monthly carbon dioxide levels (parts per million) in Mauna Loa, Hawaii



(2004-2009). The red line depicts average monthly values. The black line represents average levels corrected for seasonal cycles.
Source: Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/)

For more information, see:

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Concern about the rise in CO_2 stems from consumption of fossil fuels and clearing land of vegetation. These activities release significant amounts of CO_2, which is the dominant greenhouse gas. *Greenhouse gases* refer to a few specific gases which reduce the loss of heat from earth's atmosphere – similar to the glass in a greenhouse – thereby keeping the earth's temperature in a livable range. Since CO_2 represents 60% of the total long-lived global greenhouse gases it has become the focus of most efforts to slow and ultimately, reduce global warming. The justification for limiting CO_2 production stems from the assumption that a reduction in the use of fossil fuels and land clearing will lead to significant reductions in atmospheric CO_2. It follows that if trees can absorb excess CO_2 from the atmosphere, then humans can mitigate a portion of the anticipated future global climate change by planting trees, burning wood in place of fossil fuels, and storing carbon in trees and long-lived wood products.

Carbon dioxide isn't the only culprit in global climate change. Methane (CH_4), the natural "swamp" gas, and nitrous oxide (NO_x), a byproduct of fossil fuel combustion, are also prominent green house gases. Not all green house gases are equal in their warming potential. To help compare the warming potential of various gases, scientists have established a common measure called global warming potential (GWP) which describes the warming potential over time of greenhouse gases relative to a similar quantity of CO_2. Using the GWP measure for a 100-year period, a methane (CH_4) molecule would have a GWP of 23, while a nitrous oxide molecule (NO_x) would have a GWP of 296. [(1)] Stated plainly, NO_x has almost 300 times the warming potential of a single $C0_2$ molecule. Yet NO_x and the high-GWP gases exist in much lower atmospheric concentrations than CO_2, which contributes approximately 70% of human-induced greenhouse effect. [(2)]

Trees and Carbon Sequestration

Most grade school children learn that green plants take in CO_2 and through photosynthesis produce sugar and oxygen in the presence of sunlight. Carbon is stored throughout all plants while they are alive. Carbon is released back into the environment when trees and other carbon-based materials decompose or are burned. Because of this carbon cycle relationship, scientists and policy makers see trees as a means to capture the excess CO_2 in the atmosphere and help balance the carbon that is released through fossil fuel combustion. Estimates suggest that U.S. forests currently capture only $1/10^{th}$ of total U.S. greenhouse gas emissions. With appropriate rewards and compensation, scientists have calculated that planting new forests (afforestation), avoiding deforestation, and improving forest management could cost-effectively sequester additional carbon in the U.S. and across the world.

Table 1 shows forestry practices currently being studied for their role in capturing carbon from the atmosphere – essentially "offsetting" the carbon emissions released by the burning of fossil fuels or clearing of land. *Carbon sequestration* is the long-term storage of carbon in the terrestrial biosphere, underground, or in the oceans in an attempt to reduce or slow atmospheric concentration. Similar efforts are underway in the

[(1)] *IPCC Third Assessment Report "Climate Change 2001" (Table 6.7)*
http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/248.htm
[(2)] *EPA Climate Change – International Analyses*
http://www.epa.gov/climatechange/economics/international.html

Table 1. Forestry Practices that Sequester or Avoid Carbon Emissions (Source: U.S. EPA)

Forestry Practice	Definition (Examples)	Effect on greenhouse gases
Afforestation	Tree planting on non-forest land (pasture or marginal cropland)	Sequesters carbon in soils, roots, stem, twigs and foliage.
Reforestation	Tree planting on existing forest land (immediately after harvest or to restore denuded areas where natural regeneration not possible).	Sequesters carbon in soils, roots, stem, twigs and foliage. *Fertilization may generate some N_2O emissions.
Sustainable Forest Management	Modification of forestry practices/harvest to sequester additional carbon over time. (Lengthening rotation or retaining partial over story rather than clear cutting.)	Sequesters carbon and may avoid CO_2 emissions by altering management. *Fertilization may generate some N_2O emissions.
Preservation or avoided deforestation	Protection of forests threatened by development, land clearing, or deforestation.	Avoids CO_2 emissions via conservation of existing carbon stocks.

agricultural community to increase soil carbon through native prairie restoration, no-till cropping systems and even wetland restoration.

Reviewing the chart above, some landowners will have to modify their management practices to fully participate in current carbon offset markets. Efforts are underway to document and provide credit for the carbon content of long-lived forest products that remains out of the atmosphere for decades.

To earn carbon credits and participate in certain carbon offset markets, landowners will have to verify the extent to which their project satisfies the following criteria:

- Sustainability – An accepted organization must verify that management of the project is sustainable.
- Additionality – Landowners must show what their *baseline* of growing stock and carbon sequestration would have been under "business as usual" practices without the carbon market. Preparing a baseline inventory of existing trees or vegetation (and their carbon content) is usually required. Estimates may also be made of the carbon stored in soil under current management practices. The baseline values allow certifiers to calculate credits for the new tree growth and management that provides *additional* carbon sequestration.
- No Leakage – Landowners may need to show that their change in land use or management does not merely displace the activity, resulting in an increase in emissions elsewhere. Such displacement is referred to as *leakage.* Some verification processes are beginning to calculate leakage as an average deduction.

In most instances, verification of carbon inventory will be required by a third party. The process is likely to be fairly complex. It may require grouping small forest projects to obtain a sufficient quantity of tradable carbon to sell as offsets. As with any new enterprise, a thorough review of the costs, requirements, returns and standard due diligence is strongly recommended.

Understanding Carbon Offsets Markets

Carbon offsets refer to a financial instrument that represents a unit of greenhouse gas reduction. Purchasers "offset" their own emissions through the efforts of landowners and managers. The reason that a purchaser may be willing to purchase an offset is that it is an efficient and timely means of reducing carbon emissions rather than immediate investment in control or capture technology. As a potential supplier of carbon offsets you must decide if the price offered to you (market incentive) is sufficient to warrant you to forgo other management alternatives for your property.

Currently, there are two primary markets for carbon offsets: a **compliance market**, often denoted as "*cap and trade*" system; or a **voluntary market**, where individuals, companies and government purchase carbon offsets to mitigate their carbon emissions from travel, energy use and the like. Most offsets are associated with energy conservation and efficiency or renewable energy alternatives, such as bioenergy, wind, solar and hydroelectric dams. Policy makers are increasingly looking to forest landowners and farmers as potential carbon offset providers because of a perceived ability to provide offsets at lower cost than the more common methods.

Measuring Tree Growth and Carbon Accumulation

The task of establishing baseline carbon and accumulation rates on existing land is complex. To aid in that effort many organizations have developed online estimators or "look-up " tables that allow landowners and professionals to calculate carbon accumulation rates from average regional growth rates, management schemes and species information.

The example below is a 10-acre afforestation effort on an old pasture with low intensity management in Alamance County, North Carolina. In this example, only net carbon offsets are credited to the project because of deductions for baseline (initial inventory) carbon pools and for leakage outside the project boundaries. *Baseline* refers to the stock of carbon present in the soil and pasture grasses before tree planting. *Leakage* refers to offsite increases in greenhouse gas

Net Project Offset Potential

The net project offset potential is calculated as the annual carbon sequestered, less the baseline flux and any leakage. Results can also be viewed as carbon stock accumulation (the sum of fluxes) over the course of the project.

Metric tons (CO_2 equiv.)/year	Annual flux Years 0-5	**Annual flux** Years 5-10	**Annual flux** Years 10-15	**Annual flux** Years 15-20
Gross CO_2 estimate	47	46	37	37
Baseline CO_2 deduction	0	~1	~2	2
Net Additional CO_2	**47**	**46**	**35**	**35**
Leakage deduction	19	19	15	15
NET OFFSET POTENTIAL	**28**	**27**	**20**	**20**

Totals reflect annual carbon accumulations for 10 acres. To calculate per acre estimates, divide results by 10.

emissions caused by the project that might shift production (of pasture, in this case) to other acres outside the project boundary. As this example shows, leakage can substantially reduce the direct benefits of the project.

Each carbon credit program has a unique protocol for calculating these numbers. It is crucial to understand the procedures before entering into the carbon marketplace. More importantly, seek the advice and counsel of professionals who understand the intricacies of this rapidly developing marketplace and can explain whether entering into a carbon offset trading scheme will add or detract from your current cash flow projections.

Are Carbon Offsets in Your Future?

The U.S market for carbon offsets is in transition, and unless or until there is a mandatory cap and trade program or a carbon tax instituted, there will continue to be many unanswerable questions and uncertainty. As with any innovation, many "early adopters" will be learning their way and gaining experience for the remainder who follow. Interested individuals are encouraged to learn as much as they can about pricing, commitment period, transaction fees, inventory procedures and carbon calculations for their target crop. Your decision to trade carbon offsets should be proceeded by consultation with experienced professionals, careful deliberation and due diligence.

Summary

There is great uncertainty about carbon emissions policy, trading, and the extent to which forestry offsets will be accepted. Since climate change is a long-term global issue, regional and national strategies differ. This publication has focused only on forestry carbon offsets. Future policy will pit greenhouse gas reduction against rising energy demands. Policy discussions center around two likely market solutions, cap 'n trade or carbon emission tax legislation. Both strategies attempt to place a value on carbon to facilitate an efficient reduction of emissions (essentially creating a market price so that reduction in carbon emissions can be tracked and traded). National and global policies will likely impose additional energy efficiency standards to reduce fossil fuel consumption (carbon emissions). Additional research, development and use of improved emission controls will undoubtedly impact the future market price for carbon. Prudent tree growers should consider how energy conservation incentives, efficiency and renewable energy efforts may affect their ability to market forestry carbon offsets.

Carbon Trading: A primer for forest landowners
http://carbon.sref.info/

Carbon Trading for Landowner
http://www.sref.info/publications/online_pubs/publications/online_pubs/carbon_credits

Carbon Calculator
http://carbon.sref.info/estimating/calculator

Reforestation Afforestation Project Carbon On-Line Estimator
http://ecoserver.env.duke.edu/RAPCOEv1/

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www.ces.ncsu.edu/forestry/biomass.html

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